AC 2008-2533: INCLUDING QUESTIONS OF MILITARY AND DEFENSE TECHNOLOGY IN ENGINEERING ETHICS EDUCATION

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Including Questions of Military and Defense Technology in Engineering Ethics Education

We review the strong historical inter-relationships between the discipline of engineering and the military, and provide additional data to illustrate that these ties persist today. With the association to military and defense-related enterprises comes a host of ethical questions that have practical import. However, these questions are frequently neglected in the engineering ethics teaching materials. We argue that it is imperative to examine these issues in engineering ethics education, and that this discussion would complement movements to orient engineering around fostering peace and social justice.

1. Introduction

The co-development of technology and engineering with military technology is historically well established. Indeed, many early mechanisms were designed for waging battle, and countless engineers throughout history have worked for military institutions. Likewise, many of the first institutions of higher education to offer degrees in science or engineering have military origins. We review some of the history of engineering to substantiate this account.

We show that research and development in engineering continues to be closely related to the military and defense sectors. Using two fundamental measures – federal employment statistics and federal research obligations – we demonstrate that amongst all professions, engineering has a much higher than average proportion of disciplinary activity devoted to defense-related endeavors. For example, as derived from data provided by the US Bureau of Labor Statistics and the Department of Defense, about 3% of US workforce effort is devoted toward producing defense-related goods and services, compared with 9% for engineers, and higher in some specialized engineering fields (e.g., over 20% for aerospace engineering). As will be demonstrated, these fractions of overall disciplinary effort can be construed to underestimate the actual numbers of engineers who work on defense-related projects. With respect to research efforts, based on data from the National Science Foundation, about 50% of federally supported research in engineering is defense-related, far higher than for most other disciplines.

A variety of ethical questions surround the engineer's participation in military or defense-related work. But despite this, and despite the historically strong and persisting association between engineering and the military, surprisingly little attention is paid to questions of military, defense, or weapons research and development in engineering ethics literature. We surveyed several engineering ethics textbooks and found that less than half provide any direct attention to these issues, and fewer do so systematically. Similarly, our survey of two primary online sources, Online Ethics and the Engineering Case Library, shows that very few published cases cover these issues.

As part of their ethics education, engineering students must become aware of likelihood to encounter ethical questions in their work, and educators have a responsibility to help students develop this awareness. We argue that questions arising from military, defense, or weapons technology, research, or development are crucial for engineering students and educators to consider, not only because such work intrinsically raises serious moral questions, but also because our analysis of employment data and research funding suggests that the probability is significant that engineers will encounter such questions. Finally, careful consideration of the relationships between engineering and military or defense endeavors is essential to the engagement of engineers in the enterprises of global peace building, sustainable development, and humanitarian service.

2. Brief History of the Relationship Between Engineering and the Military

Historically, technology and the related disciplines of science and engineering have evolved in tandem with military endeavors (although our general focus is on engineering as distinct from science, the distinctions between engineering and science are less sharp during earlier periods in history). Many, if not most, technological developments have been developed in tandem with or as a result of military requirements and objectives. Work of even the earliest engineers and scientists, such as the work of Archimedes to improve the catapult (c. 250 BC), have been directed toward serving military purposes. Accounts by many historians of engineering underscore the nearly inseparable links between engineering and the military, particularly during the era (c. 17th Century) when engineering emerged as a profession in the sense defined by Davis[9]. So identified was engineering with military projects that, according to Hacker[15], "the very term 'civil engineer' appeared in the 18th century to name a new kind of practitioner: one who engineered something besides fortifications or weapons". Similar accounts of the birth of civil engineering are given in Davis[9] and Vesilind[46].

Yet, ironically, despite the emergence of the apparently separate field of civil engineering new complicities between military and civilian projects evolved. For example, from the earliest stage, Hacker[15] notes that "roads, bridges, railways, and other state-sponsored civil projects may themselves betray more than a trace of military motive". The issue of dual-use technology remains perhaps more than ever at the crux of many questions surrounding the appropriate use of technology and engineering ethics.

Not surprisingly, engineering education, particularly in France and the United States, has its roots in military academies. The first institution of higher education in the United States to grant a degree in engineering was the United States Military Academy at West Point (Davis[9]; Hacker[15]). Streett[34] describes in detail how the military culture of regimentation has infused engineering education through the 20th century.

Despite the strong historical connections between engineering and the military, the period after World War II ushered in a new era in which military support for engineering – particularly through organized, funded research & development – became dominant and institutionalized. Seely[32] describes the nearly singular support of the Department of Defense in funding basic research during the 1950s. Even the National Science Foundation was founded largely on the basis to support militarily-relevant research, as envisioned by its leading proponent Vannevar Bush[6]: "There must be more – and more adequate – military research in peacetime. … This can best be done through a civilian-controlled organization with close liaison with the Army and Navy …".

These relationships are evidenced by funding data. Mitcham[25] reports that between 1950 and 1985, 65%-70% of federal R&D funds were channeled through DOD, compared with only 1%-3% through NSF. Based on data published by AAAS[19], for the period 1986-2006, US defense R&D accounted for approximately 57% of all federal R&D expenditures (in 2006, the fraction was approximately 58%).

In addition to research, a many engineers are employed in military and defense-related work. As quoted in Shinn[33], Brown[5] observed that during the 1970s, "perhaps 40% of the world's total pool of highly qualified research people are dedicating their research skills to military projects". And according to emeritus science professor Robert Rutman in a documentary produced by the Center for Defense Information[8], "two-thirds of the scientists and engineers in the United States work for defense contractors or on defense contracts in institutions and universities".

3. Recent Data Indicating the Relationship between Engineering and the Military

We present further data to shed light on the relationship between engineering and the military. Through statistics of employment and federal research funding, we demonstrate that a large share of professional engineering effort is dedicated to military and defense work, and conversely, that military and defense work largely depends on engineers.

Employment Data. Motivated by a basic question, *how many engineers are employed in defense-related activities?*, we first examine employment data. Table 1 provides basic employment data to give a general sense of the presence of engineers in the US workforce, using data provided by the Census Bureau[37], Bureau of Labor Statics[36], and the National Science Foundation[39]. As indicated, approximately 1.4 million practicing engineers are actively employed in the United States, representing approximately 1.1% of the overall workforce. Over 3 million citizens have engineering degrees.

Table 1. General Population and Employment Data

Category	Number (1000's)	Normalized by US Population	Normalized by Total Employed
US Population (2006 est.) [37]	299,398	100.0	
Degree-aged (2006 est.) [37]	212,354	70.9	
College Degreed Individuals (2003) [39]	40,621	13.6	
US Workforce* (2006 est.) [36]	132,605	44.3	100.0
Degreed and Employed (2003) [39]	32,575	10.9	24.5
Engineering Degreed (2003) [39]	3,088	1.0	n/a
Engineering Employment* (2006) [36]	1,437	0.5	1.1

Notes. We defined "Degree-Aged" as those aged 21 and over. Normalizations are manually calculated. *Excludes self-employed.

Table 2 summarizes the total and defense-related employment of engineers in the US, categorized by engineering sub-discipline. Data for "Total Number Employed" is provided by the Bureau of Labor Statistics (BLS) *National Occupational Employment* *and Wage Estimates*[36], whereas the "Equivalent FTE Employed in Defense" is provided by the Department of Defense (DOD) *Projected Defense Purchases (DEPPS)*[38]. The "Defense Share" is manually calculated as the percentage of the occupational total comprised by equivalent defense employment. Although the BLS and DOD data are derived by different methods, we compare these data because entirely self-consistent data appears to be unavailable. Some consistency exists in that each data source is based on the Standard Occupational Classification (SOC) system for defining employment by occupation. However, the SOC designations are somewhat crude because a given company is classified as belonging to a single industry based on its primary sales.

Table 2. Employment and Equivalent Defense Employment in the US Engineering Workforce (2006 est.)

Data in 1000's of workers Occupation*	Total Number Employed [36]	Equivalent FTE Employed in Defense [38]	Defense Share (%)
Aerospace Engineering	86.7	17.6	20.3
Chemical Engineering	29.1	1.9	6.5
Civil Engineering	236.7	11.1	4.7
Electrical and Electronics Engineering	279.6	36.6	13.1
Industrial Engineers (including Health & Safety)	198.3	12.1	6.1
Materials Engineering	21.2	1.8	8.5
Mechanical Engineering	217.5	17.6	8.1
All other Engineering**	367.7	27.7	7.5
Engineering TOTAL	1,436.9	126.4	8.8
Workforce TOTAL***	132,604.9	3,724.0	2.8

FTE = "Full-time employed". *Based on the Standard Occupational Classification System (BLS). **Includes Agricultural, Biomedical, Computer hardware, Environmental, Marine, Mining, Mining Safety, Geological, Nuclear, Petroleum, and other (miscellaneous) Engineers; ***Excludes self-employed workers.

It is important to understand the meaning of "equivalent FTE employed in defense" that is provided by DOD[38]. DOD does not attempt to directly count workers. Rather, a survey of purchases by the DOD is conducted, and from this data the equivalent full time employment necessary to deliver those goods and services is estimated by employment category. These estimates include total employment efforts required to deliver both direct (e.g., the purchase of ammunition) and indirect (e.g., the purchase of paint) defense-related goods and services. However, these estimates do not include defense-related purchases by agencies other that DOD, such as DOE or NASA; whether or not the data reflects effort related to defense sales to foreign governments is unclear. Further muddying the data is the fact that some of the engineering effort reflected in the DOD data is provided by engineers in foreign countries under contract with US companies.

With these caveats in mind, our complied data indicates that about 8.8% of professional engineering effort is devoted to defense-related activities – about 3 times higher than for the overall workforce defense effort (2.8%). Some specializations, such as aerospace engineering and electrical engineering, are especially tied to defense-related activities. Somewhat greater estimates are reported by Thomson[35] and Meade & Lile[23] in the late 1990's, and our perusal of BLS and DOD data from this era corroborates these findings. Finally, we note that because federal definitions do not identify computer and software engineers as "engineers", they are excluded from Table 2. About 5.8% of workforce effort in these fields is defense-related[36].

At first glance, our calculation that 8.8% defense-share of engineering workforce effort appears to sharply contradict the previously cited estimates by Brown[5] and Rutman[8] that upwards of 40% of engineers work in defense-related industries. On further reflection, however, these data can be plausibly reconciled with our calculations. Because our calculations rely on DOD data of equivalent full time effort, it is quite possible that if the overall disciplinary effort is 8.8%, in reality, a much higher percentage of engineers are likely to be engaged in significant defense-related work as part of their employment.

From Table 2 we can also extract complementary employment effort data to indicate the share of defense productivity contributed by engineers compared with other disciplines. Approximately 3.4% (126.4/3724.0) of the total defense workforce effort is contributed by engineers. For comparison, engineers comprise only about 1.1% (1436.9/132604.9) of the national workforce. This suggests that the defense workforce is more reliant on technically trained engineers than workers in other fields.

Research Expenditures. We next consider research expenditures. Data for federal research obligations, broken down by both agency and discipline, is available from the National Science Foundation[40]. Table 3 provides projections of research obligations for FY 2007 for all designated research fields (as federally defined) and selected agencies. To illuminate the relative sources of funding within each discipline by agency, we normalize research obligations by field in Table 4. The last row of Table 4 indicates the portion of each agencies research obligations that are categorized as engineering.

Table 3. Federal Research Obligations by Field and Selected Agency (2007 projections, [40])

Field	HHS	DOD	DOE	NASA	NSF	Total
Environmental Science	449	340	341	954	646	3,636
Life Science	23,619	547	294	233	583	27,811
Math and Computer Science	186	1,018	927	70	840	3,182
Physical Science	415	521	2,417	1,132	766	5,648
Psychology	1,755	61	0	15	4	1,912
Social Science	336	17	0	1	183	1,215
Other Science	1,120	299	13	210	334	2,199
Engineering	922	3,647	2,047	1,496	694	9,487
Total	28,802	6,450	6,039	4,111	4,050	55,089

Figures in millions of dollars. Total obligations per field include obligations from agencies not listed.

Table 4. Federal Research Obligations by Agency, Normalized by Field (manually calculated from Table 3)

Field	HHS	DOD	DOE	NASA	NSF	Total
Environmental Science	12.3	9.4	9.4	26.2	17.8	100.0
Life Science	84.9	2.0	1.1	0.8	2.1	100.0
Math and Computer Science	5.8	32.0	29.1	2.2	26.4	100.0
Physical Science	7.3	9.2	42.8	20.0	13.6	100.0
Psychology	91.8	3.2	0.0	0.8	0.2	100.0
Social Science	27.7	1.4	0.0	0.1	15.1	100.0
Other Science	50.9	13.6	0.6	9.5	15.2	100.0
Engineering	9.7	38.4	21.6	15.8	7.3	100.0
Engineering Share of Agency Total	3.2	56.5	33.9	36.4	17.1	17.2

Total obligation per field includes obligations from agencies not listed.

Table 4 reveals that the field of research with the highest proportion of funding derived directly from the Department of Defense (DOD) is Engineering (38.4%), followed by research in Math and Computer Science (32.0%). Feldman[11] reported somewhat higher percentages in late 1980's for several sub-disciplines of engineering and the physical sciences. Moreover, NSF reports that about 32% of research sponsored by the Department of Energy (DOE) is defense-related[40] (a previous report[41] indicated 41%). A significant portion of the NASA research budget is also defense-related[8,28], but data specifying this appears not to be readily available. Assuming that 33% of research in DOE and NASA in each field is defense-related, about 51% of federally funded engineering research is defense related (and about 42% for Math and Computer Science).

For clarity, observe that the data in Table 4 illustrates that research obligations channeled through Health & Human Services dwarfs those of the other agencies and accounts for more than 50% of the total federal research obligation. At first glance, this appears to contradict the evidence presented in the Introduction that nearly 60% or more of all federal R&D is defense-funded[19,25]. This apparent discrepancy is reconciled by realizing that the Table 4 tallies only *research* obligations; *development* is not included (readers familiar with federal R&D data will realize that the reported total obligation in Table 4, $55,089 million, is less than half of total federal R&D expenditures). We confirmed this understanding through a discussion with a statistician at NSF, and further learned that the federal government does not track "development" funding by agency and discipline[24].

Also note that the data in Tables 4-5 is limited to *federally* sponsored research, which accounts for only about 30% of all US research expenditures[29]. We discovered that little data is available that can indicate the portion of privately funded engineering research that is defense-related. As with the employment data, statistics that have been collected to measure research activities in private industry use a classification scheme that designates a single industry description to an entire company, and these descriptions do not include designations that would distinguish defense-related activities[24].

A recent NSF report sheds some light on the defense share of engineering research in the private sector. According to this report[42], unlike research in most industrial sectors, research in the aerospace industry is primarily funded by the federal government. While this does not directly imply that engineering research in the aerospace sector is dominated by defense activities, this would be a reasonable conjecture given that defense-related employment dominates aerospace engineering more than any other category engineering [Table 2].

4. Relevance to Engineering Ethics

Ethical and moral questions surrounding military actions, development and deployment of weapons, and other defense-related activities have been debated for centuries. The basis of these questions revolves around the appropriate uses and threats of lethal force. These questions are relevant to engineering because engineers are fundamentally necessary for building the weapons of war. As Vesilind[46] puts it, "[o]ne does not necessarily need lawyers, or accountants, or journalists to wage war, but engineers are indispensable"; engineers are effectively the "gatekeepers". The strong institutional associations between engineering and the military further underscore this point.

We do not attempt to thoroughly address the array of ethical questions that arise in military or defense-related engineering work. Briefly, the engineer need consider his or her activities in (1) applied research, development, or design directly related to the development of weapons, (2) basic research, development, or design supported by the military or defense-industry, and (3) research or employment not supported by the military or defense-industry, but which might have military or defense applications. An excellent source for further examination of ethical questions related to the engineer's participation in military and defense activities is the 1989 conference proceedings *Ethical Issues Associated with Scientific and Technological Research for the Military*[25].

In light of the arguably dominant influence of military and defense-related interests in engineering, fundamental ethical questions raised that are of great practical importance to engineering and engineering education. These issues are confined neither for academic debate nor to engineers who ostensibly work in military or defense-related areas. Rather, these questions also pertain broadly to engineering practice and policy at the level of the profession, such what employment options are available to engineers and what societal needs are addressed or ignored as a result of the national research funding priorities.

Yet it appears that students are unaware of the connections between engineering and the military as they begin their education. In our experience, when discussed, students find ethical questions relating engineering and the military or defense applications to be intellectually stimulating and thought-provoking, but they less frequently perceive them to be relevant. This is unfortunate, for there is a reasonable chance that they will encounter these questions as they seek employment or graduate studies. Unger describe this situation as follows[43]:

> The great majority of [engineers] are not in business for themselves. They are compelled to choose among limited employment opportunities. A high percentage of engineers are employed, directly or indirectly, on military-related projects, but this use of engineering talent is not a result of wholly free choices engineers have made.

In another piece, Unger further remarks that a dilemma faced by engineers is that even when not readily apparent, an engineer's work might contribute to causes that he or she does not support[44].

Furthermore, beyond the scope of choices made by individual engineers or engineering students, the issues of military or defense activities in engineering are relevant to engineering and engineering education at the disciplinary level. As Feldman contended[11],

> But the political obedience inherent in military dependency is not just the reflection of what overt political stands military-sponsored scientists take on war and peace. Rather, military dependency determines what kinds of science are taught and what kinds of science are practiced by graduating students. There is a close relationship between science and engineering curriculums and the sponsors of faculty research …"

This view was recently voiced by Manion & Kam[20], who wrote "one only needs to look at the history of the engineering profession to see how closely engineering schools and large corporations work together to tailor an engineering curriculum suited to the immediate needs of the military-industrial complex, and Riley[27], quoting sociologist Robert Zussman, points out that "because engineers are embedded in industry or the military, they typically serve the ends of profit-making, or defense, and it has not traditionally been considered a professional duty to question those ends".

Our data analysis of employment and research funding data substantiates many of these observations, and shows that the possibility of the engineer performing of military-related work is high. Therefore, we contend that related ethical questions and topics must be included in engineering ethics.

However, from our own experience, ethical questions related to engineering and the military do not appear to be raised in most standard treatments of engineering ethics. This observation seems to correspond with the description of engineering ethics provided by Manion & Kam[20], in which initial approaches to engineering ethics were narrowly defined and excluded larger questions of the role of the engineer in society:

> Prior to the 1980s, the primary focus for professional ethics tended to be 'internalist' in nature. The primary focus was with interpersonal behavior among professionals or between professionals and client. Relevant topics included codes of conduct, conflict of interest, questions of fair advertising, and improper competition. Since then, the scope of professional ethics has broadened to include responsibilities of individual practicing engineers to society, as well as the larger, social responsibilities of engineers. This broadened sense of professionalism and ethics implies broad responsibilities for professional engineers, such as ensuring the safety, health, and welfare of the public in the practice of their professional duties, protecting the environment, and, generally, guarding the interest or welfare of society in all aspects where engineering activity might have an effect. Although not everyone subscribes to such a broad definition of engineering responsibility, the literature is growing in this direction.

We decided to quantify the presence of questions related to military or defense-related engineering in primary engineering ethics resources by surveying 17 engineering ethics texts that were locally available to us. We studied these texts for specific references to defense, military, weapons (and examples thereof, such as bombs and missiles), war, conflict, and other similar topics. We determined the degree to which any of these topics or issues were covered, particularly by documenting if any of these topics or issues were referenced in the index, constituted case studies or extended topics of discussion, or were prominently presented, such as by appearing in the table of contents.

The results of our survey are summarized in Table 5. In agreement with our informal observations, we found a general absence of these issues in the standard literature. Even among texts that reflect the broader sense of professional and social responsibilities, several omit treating matters of military, defense, or weapons engineering directly. Specifically, of the 17 textbooks surveyed, only 7 include any substantive coverage of military or defense-related issues, and fewer place these questions prominently. Of the 6 published since 2000, 3 cover such issues. While these issues are covered by several of our colleagues in their courses, general treatment is largely absent in the standard texts.

Table 5. Content of Engineering Ethics Texts Treating Military or Defense-related Activities as Issues of Engineering Ethics.			
Author/Book	Contents/ Chapter	Index	Issue
1. Alger, Christensen, and Olmsted [1] Ethical Problems in Engineering, 1965	NO	NO	NO
2. Armstrong, Dixon, and Robinson [2] The Decision Makers: Ethics for Engineers, 1999	NO	NO	NO
3. Baum [3] Ethics and Engineering Curricula, 1980.	NO	NO	NO
4. Baura [4] Engineering Ethics: An Industrial Perspective, 2006.	NO	NO	NO
5. Fleddermann [12] Engineering Ethics, 1999.	NO	YES	YES
6. Florman [13] The Existential Pleasures of Engineering, 2nd Ed. 1994	NO	NO	NO
7. Gorman, Mehalik, and Werhane [14] Ethical and Environmental Challenges to Engineering, 2000.	NO	NO	NO
8. Harris, Pritchard, and Rabins [16] Engineering Ethics: Concepts and Cases, 3rd Ed. 2004.	NO	YES	YES
9. Herkert [17] Social, Ethical, and Policy Implications of Engineering, 2000.	N/A	N/A	YES
10. Johnson [18] Ethical Issues in Engineering, 1991.	NO	YES	YES
11. Mantell [21] Ethics and Professionalism in Engineering, 1964.	NO	NO	NO
12. Martin and Schnizinger [22] Ethics in Engineering, 3rd Ed., 2000.	YES	YES	YES
13. Schaub and Pavlovic [30] Engineering Professionalism and Ethics, 1983.	NO	NO	YES
14. Scholssberger [31] The Ethical Engineer, 1993.	NO	NO	NO
15. Unger [45] Controlling Technology: Ethics and the Responsible Engineer, 2nd Ed., 1994.	NO	YES	YES
16. Vinck [47] Everyday Engineering, 2003.	NO	NO	NO
17. Whitbeck [48] Ethics in Engineering Practice and Research, 1998.	NO	NO	NO
Contents/Chapter: Mention cited in table of contents or chapter devoted to topic Index: topic identified in Index according to terms "military*, defense, weapon*, conflict, war Issue: topic appears substantively in text, such as in case study			

As another measure of coverage of military and defense questions in engineering ethics literature, we surveyed online sources. At the Online Ethics website[26], we examined 165 cases and essays under the heading "Professional Practice". Of these articles, 4 (2.4%) covered the topic, compared with 16 (9.7%) dealing with conflicts in the workplace related to reporting problems to management and 12 (7.3%) dealing with environmental issues. We also examined 297 cases and essays under the heading "Responsible Research". Of these articles, 1 (0.3%) dealt with military or defense issues. For comparison, 43 (14.5%) dealt with issues in human subject research, and 39 (13.1%) dealt with authorship issues.

We also examined Engineering Case Library[10] (ECL). Of the 261 cases contained in the ECL, only 15 (5.7%) were identified that contain at least one key word from the following set: {military, defense, weapon, war, army, navy, marine, missile, bomb, gun}. Of these 15 cases, only 6 dealt directly with some aspect of ethics related to performing military or defense engineering.

Given the great influence that military and defense-related interests exert in engineering and engineering education, the data that we collected demonstrates that ethical questions related to military or defense-related engineering are insufficiently treated. While many individual instructors are addressing these questions in their courses, we recommend that they be more frequently and thoroughly treated in the standard texts and resources in engineering ethics education.

5. Conclusions and Discussion

We reviewed the strong institutional ties between the profession of engineering and the military, citing historical evidence and providing our own recently compiled evidence from employment and research funding data. Despite the fact that there are limitations in our data, we argued that there is a high probability that an engineer, whether in professional practice or research, will confront the possibility of conducting defense-related work during the course of his or her career. To improve the quality of the evidence on which we base these conclusions, we intend to conduct further research by, for example, attempting to collect direct counts of engineers who are employed in defense-related activities. Such data might be available from the Survey of Industrial Research and Development, but this data is not readily available to the public[24].

Given the strong connections between engineering and the military, and the array of important and related ethical questions, it follows that ethical questions of military or defense-related work should be substantively treated in engineering ethics courses and textbooks. However, our review of several standard engineering ethics teaching resources illustrates that these questions are treated infrequently and insufficiently. We strongly advocate for more standard and general inclusion of these issues in engineering ethics teaching materials, and we otherwise urge engineering educators and other ethics educators to address issues of military and defense-related work in some meaningful way.

We believe that one useful approach to augmenting the literature is to develop case studies and that articulate the experiences of engineers who have chosen or avoided military or defense-related work specifically for ethical or moral reasons. While many such accounts seem to be written about scientists (particularly atomic scientists), relatively few seem to be available about engineers.

Just as with the discussion of any ethical matter, students will hold varying perspectives and opinions regarding the role of the engineer in military and defense-related engineering. Certainly the role of the educator is not to indoctrinate students with his or her own point of view, but it is paramount that the educator prepare his or her students to exercise their own ethical judgment by helping them to build awareness of situations – in this case the possibility of performing military or defense-related work – that they are reasonably likely to encounter.

Moreover, echoing Riley's general point, it is imperative that engineers understand the broader contexts in which they work in order that they might actively choose how to direct their energies[27]. Indeed, in addition to their relevance to individual moral decisions, ethical questions must be dealt with at the level of the discipline.

In his recent book *Peace Engineering: When Personal Values and Engineering Careers Converge*, Vesilind[46] argues that the evolution of a new type of engineering called "Peace Engineering" is emerging as more and more young engineers are seeking applications of engineering beyond the entanglement between military and civilian engineering applications. And engineering researchers and organizations are sponsoring conferences and activities oriented around humanitarianism, peace, and social justice. In particular, Catalano[7] recently articulated how a peace paradigm might be incorporated into the ABET criteria. An invigorated discussion of ethical issues in engineering relating to military and defense-related applications will greatly complement these movements and provide a body of knowledge that will help engineering students decide how to direct their efforts, particularly with respect to the enterprises of humanitarian service, sustainable development, and global peace building.

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